

Taxonomic Status of Striped Field Mice (Mammalia: Rodentia) from Wando Island, Korea

Hung Sun Koh, Bo Yeong Lee, Yong Ki Kim, Sang Kyu Yoo and Byeong Kug Yang

(Department of Biology, Chungbuk University, Cheongju 361-763, Korea)

ABSTRACT

Thirty one morphometric characters of striped field mice (*Apodemus agrarius*) from eight localities in Korea were analyzed by multivariate methods in order to confirm taxonomic status of specimens from Wando island. Two subgroups were recognized: a small-size form from six localities (Mt. Taebaek, Mt. Weolak, Cheongju, Mt. Chiri, Kunsan, and Jin island) and a large-size form from Wando island and Cheju island. It is confirmed that the small-size form from six localities is *A. a. coreae*, as described by Thomas (1908), and that the large-size form from Cheju island is *A. a. chejuensis*, as named by Johnson and Jones (1955). Furthermore, it is confirmed that large-size specimens from Wando island is subspecies *A. a. chejuensis*, as suggested by Koh (1989). In future, analyses with specimens from islands in southern coasts are necessary to clarify the taxonomic status of *Apodemus agrarius* in Korea.

Key words: Taxonomy, *Apodemus agrarius chejuensis*, Wando Island, Korea.

INTRODUCTION

Striped field mice, *Apodemus agrarius* Pallas 1771, inhabit from western Germany to Korea, and most of subspecies were designated on the basis of slight differences in pelage colour and/or body size (Corbet, 1978).

Thomas (1908) described striped field mice from the Korean peninsula as *A. agrarius coreae* (type locality; Munkyeong). Johnson and Jones (1955) recognized four subspecies of *A. agrarius* from Korea: *A. a. manchuricus* in the extreme northern part; *A. a. coreae* throughout the major portion of the peninsula; *A. a. pallascens* (type locality; Kunsan) in the coastal lowlands of southern and southwestern Korea; and *A. a. chejuensis* on Cheju island (type locality; Mosulpo). They also noted

that *A. a. pallescens* is slightly larger in morphometric characters than *A. a. coreae* and that *A. a. chejuensis* is the largest subspecies.

The methods of numerical taxonomy based on equal weighting and overall similarity seemed to have potential for the resolution of taxonomic problems at the infraspecific level (Flake and Turner, 1968). In morphometric analyses with specimens of three subspecies of *A. agrarius* from ten localities of Korea, it was revealed that *A. a. pallescens* is a synonym of *A. a. coreae* (small-size form) and that *A. a. chejuensis* is distinctly large (Koh, 1986). In the analyses with specimens of two subspecies of *A. agrarius* from 17 localities of southwestern coasts, three specimens from Wando island formed a large-size subgroup with the specimens from Cheju island (Koh, 1989).

In this paper, 25 specimens of Wando island were analyzed for the morphometric comparison with the specimens of two subspecies of *A. agrarius* (subspecies *coreae* and *chejuensis*) from Korea in order to clarify the taxonomic status of Wando island specimens.

MATERIALS AND METHODS

Sexual variation was not significant, but age variation was evident in *Apodemus agrarius* (Koh, 1983). Juveniles, subadults, and old adults were not used, and 275 specimens of young and middle-aged adults from eight localities in Korea, representing two subspecies (*coreae* and *chejuensis*), were analyzed (Table 1 and Fig. 1).

Four external and 27 cranial characters were measured (for details see Koh, 1983). Sample statistics such as mean were calculated by subprogram DESCRIPTIVE of SPSS/pc+ program: discriminant analysis was also performed by subprogram DISCRIMINANT. Principal component analysis and cluster analysis were carried out using subprogram EIGEN and SAHN of NYSYS/pc program, respectively: minimum spanning tree was also produced by subprogram MST.

Table 1. Specimens of striped field mice, *Apodemus agrarius* from eight localities in Korea

Subspecies name	Locality	No. of specimens	OTU
<i>A. a. chejuensis</i>	Mt. Hanla, Cheju island	47	1
	Wando island, Cheonlanam-Do	25	2
<i>A. a. coreae</i>	Jindo island, Cheonlanam-Do	20	3
	Kunsan, Cheonlabuk-Do	28	4
	Mt. Chiri, Cheonlanam-Do	21	5
	Cheongju, Chungchongbuk-Do	85	6
	Mt. Weolak, Chungchongbuk-Do	35	7
	Mt. Taebaek, Kangwon-Do	14	8
Total		275	

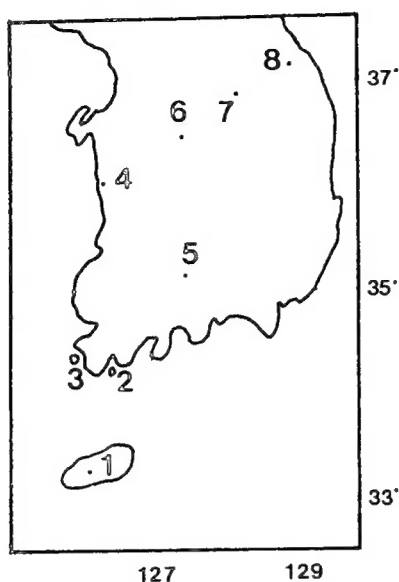


Fig. 1. A map showing eight OTUs of specimens in *Apodemus agrarius* from Korea. The subspecies name and number of specimens in each OTU are given in Table 1.

RESULTS

Two dimensional plottings from discriminant analysis with eight OTUs in *Apodemus agrarius* are shown in Fig. 2 (numerals indicate centroids of OTUs and minimum spanning tree is superimposed on the plots). Functions I, II, and III represented 53.5, 17.3, and 10.7 percent of the variance, respectively (81.5 percent in total). Two subgroups were revealed: large-size form (OTUs 1 and 2) and small-size form (OTUs 3, 4, 5, 6, 7, and 8).

Two dimensional configurations of eight OTUs of *A. agrarius* by principal component analysis are shown in Fig. 3 (minimum spanning tree is superimposed on the plots). Factors I, II, and III represented 78.6, 8.4, and 5.0 percent of the variance, respectively (90 percent in total). Two subgroups were recognized, as revealed by discriminant analysis mentioned above. Eight OTU's were also grouped by cluster analysis of average linkage with taxonomic distances, as shown in Fig. 4. Two subgroups mentioned above were also revealed.

In summary, two subgroups were recognized: a large-size form from two localities of Cheju island and Wando island and a small-size form from six localities of Jindo island, Kunsan, Mt. Chiri, Cheongju, Mt. Weolak, and Mt. Taebaek. The large-size form and the small-size form are *A. a. chejuensis* and *A. a. coreae*, respectively.

DISCUSSION

Sneath and Sokal (1973) stated that there are no satisfactory methods for telling whether clustering

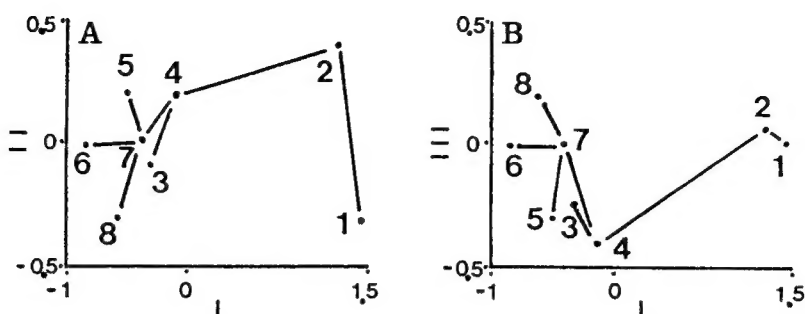


Fig. 2. Plottings of eight OTUs in two subspecies of *Apodemus agrarius* in Korea by discriminant analysis. Numerals indicate the group centroid and minimum spanning tree is superimposed on the plots. A, OTUs ordinated with functions I vs. function II. B, OTUs ordinated with function I vs. function III. The subspecies name and locality of each OTU are given in Table 1.

or ordination is appropriate. In this paper based on discriminant analysis (Fig. 2), principal component analysis (Fig. 3), and average linkage cluster analysis (Fig. 4) with morphometric characters, two subgroups were recognized: large-size form (OTUs 1 and 2) and small-size form (OTUs 3, 4, 5, 6, 7, and 8).

Jones and Johnson (1965) reported four subspecies of *Apodemus agrarius*: *manchuricus* in the extreme northern part, *pallescens* in the coastal lowlands of southern and southwestern Korea, *coreae* throughout the major portion of the peninsula, and *chejuensis* in Cheju island. Koh (1986) performed morphometric analysis with specimens of *A. agrarius* from ten localities in Korea, including eight specimens from Kunsan and four specimens from Mokpo [subspecies *pallescens* by Jones and Johnson (1965)], and concluded that subspecies *pallescens* is the synonym of subspecies *coreae*.

Furthermore, in morphometric analysis with specimens of *A. agrarius* from 12 localities in Korea, including eight specimens from Kunsan, 18 specimens from Jin island, and three specimens from Wando island, Koh (1989) found that Kunsan and Jin island specimens formed a small-size form with other specimens of *A. a. coreae* and that Wando island specimens formed a large-size form with specimens from Cheju island. It was confirmed that subspecies *pallescens* is the synonym of subspecies *coreae* and it was suggested that Wando island specimens are subspecies *chejuensis*.

Jones and Johnson (1965) noted that *A. agrarius chejuensis* is larger, both externally and cranially, than any other described subspecies of *A. agrarius* and is easily distinguished from the other known subspecies, although Corbet (1978) stated that the insular form from Cheju island is rather large but is not very distinctive. Koh (1991) and Koh *et al.* (1997) concluded in morphometric analyses with seven subspecies from Asia that subspecies *chejuensis* is the largest-size form, as noted by Jones and Johnson (1965).

Mayr and Ashlock (1991) suggested that a classification should be the product of all available characters distributed as widely and evenly as possible over the organisms analyzed. Koh (1982, 1987, 1989) reported that the karyotype of *A. agrarius coreae*, including Wando island specimens, and *A. a. chejuensis* are the same. However, Koh and Yoo (1992) found in their analysis of mtDNA restriction fragments that Wando island specimens are distinct from specimens of Cheongju and Haenam.

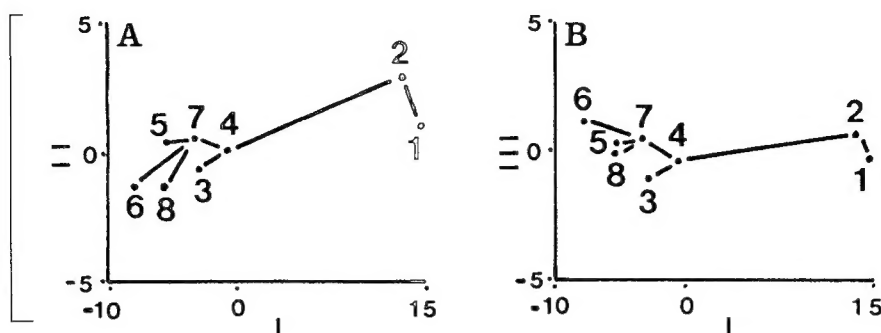


Fig. 3. Projections of eight OTUs in two subspecies of *Apodemus agrarius* in Korea by principal component analysis. Numerals indicate OTUs and minimum spanning tree is superimposed on the plots. A, OTUs ordinated with factor I vs. factor II. B, OTUs ordinated with factor I vs. factor III. The subspecies name and locality of each OTU are given in Table 1.

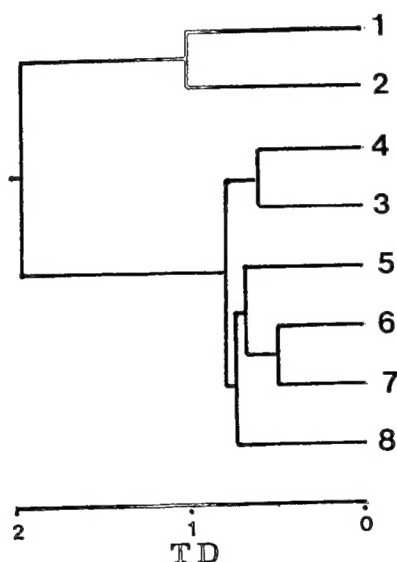


Fig. 4. Grouping of eight OTUs in two subspecies of *Apodemus agrarius* from Korea by cluster analysis of average linkage with taxonomic distances (TD). The subspecies name and locality of each OTU are given in Table 1.

In this paper (Figs. 2, 3, and 4) with *A. agrarius* from eight localities in Korea, including 28 specimens from Kunsan, 20 specimens from Jin island, and 25 specimens from Wando island, two subgroups were revealed: a large-size form from Cheju island and Wando island and a small-size form from Jin island, Kunsan, Mt. Chiri, Cheongju, Mt. Weolak, and Mt. Taebaek [Kunsan, Jin island, and Wando island are located within the distribution range of the subspecies *pallescens* by Jones and Johnson (1965)]. It is concluded that the small-size form from six localities is *A. a. coreae*, as described by Thomas (1908), and that the large-size form from Cheju island is *A. a. chejuensis*, as named by Johnson and Jones (1955). Moreover, in this paper (Figs. 2, 3, and 4) it is confirmed that large-size specimens from Wando island is *A. a. chejuensis*, as suggested by Koh (1989). Continental islands have faunas very similar to those on the mainland, but species composition in some islands may be explained by an equilibrium resulting from a balance of immigration by extinction (Gorman,

1979). Wando island is one of continental islands, and it was supposed that small-size population of striped field mice were extinct and replaced by large-size population of striped field mice immigrated from Cheju island by humans. Geographically isolated populations may be either species or subspecies (Wiley, 1982), and it is preferable for various reasons to treat allopatric populations of doubtful rank as subspecies (Mayr and Ashlock, 1991).

In future, further analyses with specimens from islands in southern coasts are needed to clarify the classification of *A. agrarius* in Korea.

REFERENCES

- Corbet, G.B., 1978. The Mammals of the Palearctic region: A taxonomic review. British Museum (Nat. Hist.), Cornell University Press, London, pp. 137-138.
- Flake, R.H. and B.L. Turner, 1968. Numerical classification for taxonomic problems. *J. Theoret. Biol.*, **20**: 587-591.
- Gorman, M., 1979. Island ecology. Chapman and Hall, London, pp. 79.
- Johnson, D.H. and J.K. Jones, 1955. Three new rodents of the genera *Micromys* and *Apodemus* from Korea. *Proc. Biol. Soc. Washington*, **68**: 167-172.
- Jones, J.K. and D.H. Johnson, 1965. Synopsis of the lagomorphs and rodents of Korea. *Univ. Kansas Publ. Mus. Nat. Hist.*, **16**: 357-407.
- Koh, 1982. G- and C-banding pattern analysis of Korean rodents: I. Chromosome banding patterns of striped field mice (*Apodemus agrarius coreae*) and black rats (*Rattus rattus rufescence*). *Kor. J. Zool.*, **24**: 81-92.
- Koh, H.S., 1983. A study of age variation and secondary sexual dimorphism in morphometric characters of Korean rodents: I. Analysis on one subspecies of striped field mice, *Apodemus agrarius coreae* Thomas, from Cheongju. *Kor. J. Zool.*, **26**: 125-134.
- Koh, H.S., 1986. Geographic variation of morphometric characters among three subspecies of striped field mice, *Apodemus agrarius* Pallas (Muridae, Rodentia), from Korea. *Kor. J. Zool.*, **29**: 272-282.
- Koh, H.S., 1987. Systematic studies of Korean rodents: III. Morphometric and chromosomal analyses of striped field mice, *Apodemus agrarius chejuensis* Jones and Johnson, from Jeju-Do. *Kor. J. Syst. Zool.*, **3**: 24-40.
- Koh, H.S., 1989. Systematic studies of Korean rodents. V. Morphometric and chromosomal analyses on island populations of striped field mice (*Apodemus agrarius coreae*) in southwestern coasts of the Korean peninsula. *Kor. J. Syst. Zool.*, **5**: 1-12.
- Koh, H.S., 1991. Morphometric analyses with eight subspecies of striped field mice, *Apodemus agrarius* Pallas (Rodentia, Mammalia), in Asia: The taxonomic status of subspecies *chejuensis* at Cheju island in Korea. *Kor. J. Syst. Zool.*, **7**: 179-188.
- Koh, H.S., Y.K. Kim, W.J. Lee, J. Wang, and H. Lu, 1997. Morphometric variation of six subspecies of striped field mouse, *Apodemus agrarius* Pallas (Mammalia, Rodentia), from China and Korea. *Kor. J. Biol. Sci.*, **1**: 25-29.
- Mayr, E. and P.D. Ashlock, 1991. Principles of systematic zoology. McGraw-Hill Inc. New York, pp. 475.
- Sneath, P.H.A. and R.R. Sokal, 1973. Numerical taxonomy. W.H. Freeman and Co., San Francisco, pp. 573.

- Thomas, O., 1908. The Duke of Bedford's zoological exploration in eastern Asia: VI. List of mammals from the Shantung peninsula, N. China. Proc. Zool. Soc. London, pp. 5-10.
- Wiley, 1982. Phylogenetics: The theory and practice of phylogenetic systematics. John Wiley & Sons, New York, pp. 439.

RECEIVED: 12 January 1998

ACCEPTED: 12 February 1998

한국의 완도에 서식하고 있는 등줄쥐(포유강: 설치목)의 분류학적 위치

고 흥 선 · 이 보 영 · 김 영 기 · 유 상 규 · 양 병 국

(충북대학교 생물학과)

요 약

완도산 등줄쥐의 분류학적 위치를 재검토하기 위해, 한국의 8개 지역에서 채집한 등줄쥐(*Apodemus agrarius*)의 31개 형태적 형질들을 다변량분석방법으로 분석하였다. 두 군으로 나누어 졌는데, 6개 지역(태백산, 월악산, 청주, 지리산, 군산, 진도)의 작은 형과 2개 지역(완도, 제주도)의 큰 형이었다. 6개 지역의 작은 형은 Thomas(1908)가 밝힌 대로 *A. a. coreae*이고, 제주도 지역의 큰 형은 Johnson과 Jones(1955)이 기재한 대로 *A. a. chejuensis*임이 확인되었다. 뿐만 아니라, 완도의 큰형은 Koh(1989)가 제안한대로 *A. a. chejuensis*임도 확인되었다.